THE STATE CORPORATION COMMISSION
OF THE STATE OF KANSAS
BEFORE COMMISSIONERS: Pat Apple, Chairman
Shari Feist Albrecht
Jay Scott Emler

In the Matter of the Application of Unit Petroleum Company to authorize injection of saltwater into the Mississippi formation at the Royce A #1 enhanced recovery well, located in Section 16, Township 25 South, Range 9 West, Reno County, Kansas.
Docket 19-CONS-3097-CUIC
CONSERVATION DIVISION
License No. 33596

TESTIMONY OF FELIX REVELLO
December 3, 2018

Q. What is your name?
A. Felix Revello

Q. Where do you reside?
A. Pawnee Township, Pawnee County, Kansas

Q. As the crow flies, how far is your home from the Unit Petroleum Injection well site?
A. Approximately, 60 miles. Note that, here at my home, I have already felt two earthquakes from induced seismicity from injection wells in southern (Harper and/or Sumner County) Kansas. They were on February 13, 2016 and September 3, 2016.

Q. Are you one of the protestants In this matter?
A. Yes.

Q. What is the purpose of your testimony?
A. I am concerned about four issues related to the proposed EOR injection well. First Issue: Damage to historic structures and Kansas' economy. Second Issue: Potential for induced seismicity. Third Issue: Potential for groundwater contamination. Fourth Issue: Apparent mischaracterization of the purpose of the proposed injection well as an EOR well.

Q. What is your concern regarding your First Issue (Damage to Historic Structures and KS Economy)?
A. Hutchinson has already felt earthquakes originating from wells as distant as southern Kansas and northern Oklahoma. Operating a 10,000 barrel per day injection well in Reno County inevitably leads to stronger, more damaging earth quakes in the City. USGS reports that South Hutchinson has experienced 7 earthquakes of 2.5 or greater magnitude in the past 7 months: March 1 (3.1), March 8 (3.4), March 18 (2.8), April 14 (3.2), April 17 (2.9), April 20 (2.5) June 4 (2.6).

Supposedly, as a citizen who lives outside Reno County, I have no legal interest in the consequences of such earthquakes. But as a Kansan who enjoys routinely doing business in and occasionally touring Hutchinson with out-of-state friends, I am familiar with the values that city offers all Kansans. I am especially concerned for the beautiful and irreplaceable historic structures downtown. They were not built to withstand earthquakes. I enjoy seeing them and the businesses they shelter. I would miss any of them if they are destroyed or so badly damaged they will have to be demolished. Losing any of these landmarks will be costly, economically and psychologically, to Hutchinson residents and Kansas tourism. Businesses and civic organizations have invested a lot in these structures, including the recently restored Fox Theatre. Even modern structures such as the Cosmosphere could be at risk. Furthermore, every Kansan has a stake in tax revenues lost when these buildings and their businesses are damaged or destroyed. Such losses will come from our overall economy that history tells us will never be compensated for by injection well operators.

I likely will incur the additional personal cost of purchasing earthquake insurance for my home now that this well and the others that are sure to follow move closer to my home area. Again, this is a cost that many Kansans living inside and *outside* Reno County will bear. So, all of us living in the earthquake zone have a financial interest, especially as our walls and foundations crack.

Q. What is your concern regarding your Second Issue (Potential for induced seismicity)?
A. The formations within, above and below the target formation in this region are highly complex with anticlines, reverse faults, cracks and similar. This complexity seems to make them vulnerable to induced seismicity from the high rate and pressure proposed by the applicant. In particular, the proposed/requested injection rate of 10,000 barrels/day is at the threshold rate found by researchers as likely to cause induced seismicity. I cite the report entitled, "Fluid Injection Wells Can Have a Wide Seismic Reach" in *Earth and Space Science News*. Specifically, I point to the passage in this report stating, "A study of the central and eastern United States found that an earthquake is statistically more likely to occur near wells injecting more than 300,000 barrels per month than near wells injecting at lower rates [*Weingarten et al.*, 2015]." Of course, 10,000 barrels/day equals 300,000/month. Compounding this concern, one SWD well and two EOR wells already operating in Section 16 contribute to the potential for induced seismicity by the proposed well. Note further that the above cited report was produced by the Kansas Geological Survey.

Reinforcing this concern for widespread faulting is a report by Richard D. Miller and Jianghai Xia for the Kansas Geological Survey in "High-Resolution Seismic Reflection Investigation of a Subsidence Feature on U.S. Highway 50 Near Hutchinson, Kansas for the Kansas Geological Survey in "High-Resolution Seismic Reflection Investigation of a Subsidence Feature on U.S. Highway 50 Near Hutchinson, Kansas." Here researchers report, "Natural dissolution of the Hutchinson Salt is not uncommon in Kansas and has been occurring for millions of years (Ege, 1984). Faults extending up to Pleistocene sediments containing fresh water under hydrostatic pressure are postulated as the conduits instigating salt dissolution and subsidence along the western boundary of the salt in Kansas (Frye and Schoff, 1942). Paleosinkholes resulting from dissolution of the

salt before Pleistocene deposition have been discovered previously with high resolution seismic surveys (Anderson et al., 1998)."

An article on the Independent Petroleum Institute of America website, "The Mississippian Lime: Not New, But Reinvented" reinforces concerns that the geology, despite assertions by some, is complex and can cause problems. It states, "The Mississippian Lime itself has a *complex and varied geology*." Complexity suggests much faulting, discontinuities, etc.

Another interesting and scholarly paper by W. Lynn Watney (Kansas Geological Survey, The University of Kansas), "Fluid Migration and Accumulation within the Mississippi: Why 2% Oil Cut Here, 15% Oil Cut one Mile Away, Search and Discovery" tends to further support understanding that the Mississippi Limestone is complex and highly faulted. Quoting, "The significance of contemporaneous and post-depositional structural deformation of the MLP strata is unfolding as larger seismic volumes are acquired and horizontal wells drilled. Tectonism that peaked in the Atokan includes growing evidence for widespread strike-slip fault motion that extended well beyond sites of core tectonism. Directed stresses, occurring pre- and postpeak tectonism, episodically reactivated basement weaknesses, affecting deposition, diagenesis, local thermal maturation, and petroleum migration. Local structural expression of strike-slip faults, such as flower structures, restraining bends, and step-over and relay ramps, offers an additional means to improve prediction of the sweet spots. Effectiveness of horizontal wells and their completions are dependent on structure, rock strength, and stress field. Faults and fractures are often subtly expressed in seismic due to small offsets and discontinuous traces at the level of the Mississippian. Improved resolution will require methods and techniques in seismic acquisition and seismic attribute processing, in addition to careful logging and interpretation of well data."

What all of the above means is that all this faulting leads to potential induced seismicity. Furthermore, water pollution by injected water following natural faults/fractures into potable water formations (explored further under Third Issue Below) is a companion concern.

Q. What is your concern regarding your Third Issue (Potential Groundwater Contamination)?

A. Injecting water at such high volume and pressure will lead to intrusion into potable groundwater formations by way of cracks in the complex highly fractured overlying formations. Casing failure could lead to contamination of groundwater. Even without casing failure, there are no guarantees that breakout between formations (through faults/cracks) won't occur to allow injected fluids to simply follow the outside of well casings up and into groundwater formations. The fact that such failures occur is documented by Richard D. Miller and Jianghai Xia, for the Kansas Geological Survey in "High-Resolution Seismic Reflection Investigation of a Subsidence Feature on U.S. Highway 50 Near Hutchinson, Kansas." Here, researchers report, "Salt dissolution sinkholes are found in all areas of Kansas where the Hutchinson Salt is present in the subsurface. Sinkholes have been definitely correlated to failed containment of disposal wells injecting oil field brine wastewater using stem pressure tests and/or seismic

reflection investigations at a variety of sites throughout central Kansas (Steeples et al., 1986; Knapp et al., 1989; Miller et al., 1995; Miller et al., 1997)." To summarize, the investigation above documents that there are multiple faults in Reno County that serve as conduits into groundwater formations.

Q. What is your concern regarding your Fourth Issue (Apparent mischaracterization of well as an EOR well)?
A. There appear to be a number of inconsistencies between the stated purpose on the application for the Royce A #1 well to serve solely EOR purposes:

First Inconsistency- Although the application states that the well would be used for EOR, the related public notice requests "authorization for disposal of produced water into the Mississippian formation in the Royce A #1 well…" in addition to EOR purposes.

Second Inconsistency- In email communication between Rene Stuckey of KCC and me, Rene states, "You make reference to a disposal well but this well is actually an enhanced recovery well. This means the water is being placed back into the formation from where it came." However, only 4,613 barrels of oil were produced in all of 2017; consequently, it is unlikely that 10,000 barrels of produced water/day is coming from existing operations in the Langdon formations. This indicates that produced water is coming from other sources, many other sources. Perhaps, there is a miscommunication between myself and Rene. Or, maybe Rene includes produced water from other Mississippian Formations. Whatever the case, 10,000 barrels/day is excessive (when added to injections from nearby SWD and *nominal* EOR wells) and perhaps detrimental for EOR purposes from what I've seen in the literature.

Third Inconsistency- The position of this well relative to producing wells and other injection wells in Section 16 (and vicinity) does not comply with standard waterflood well patterns I see in petroleum industry informational resources. These standard patterns were developed for economic efficiency from a standpoint of oil recovery. That Royce A #1 meets any measure of economic efficiency solely for oil recovery is highly suspect.

These apparent inconsistencies indicate the well is a disposal well.

Q. Are you categorically opposed to injection wells?
A. I am definitely not opposed to injection wells when they are operated safely and honestly. Returning produced water to the formation(s) from where it comes is a good environmentally healthy option when done correctly.

Q. What are you requesting the Commission to do in this matter?
A. <u>First</u>- The KCC needs to cut the allowable rate of injection well below the 10,000 barrels/day threshold as suggested in the report, "Fluid Injection Wells Can Have a Wide Seismic Reach", cited earlier in this testimony to reduce the risk of induced seismicity.

Second- The KCC should deny the application and ask the applicant to reapply for a "Disposal" permit, reflecting the true character of the proposed use and stating a much lower (safer) injection rate.

Third- If this is truly a waterflood EOR, it will either work or not work after a period of time. KCC needs to set a reasonable deadline, based on common industry standards, at which the EOR permit is revoked and well plugged. This will prohibit a well operating under an EOR permit from being used indefinitely for SWD purposes.

Fourth- The KCC or applicant should offer free water tests to water well owners within the half-mile radius of Royce A #1 prior to injecting produced water.

Fifth-KCC should monitor pore pressures monthly in nearby wells in the target formation to determine if this well is increasing formation pressures, especially if 10,000 barrels/day is approved.

Failure to follow the above recommendations risks public health, safety and Kansas economy. The last two recommendations will provide baseline data necessary to evaluate the effects of this well, if approved. (Do the science!) If operator is not required to comply with all of the suggestions, KCC should not approve the application for the well.

Q. Does this conclude your testimony?
A. Yes.

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